

under consideration and that very quickly thereafter there will be a marked indraft of cool air from the waters off the coast, a corresponding fall in temperature over the interior, and the beginning of the eastward movement of the atmospheric fault itself. Due to the peculiar atmospheric conditions on the west coast the formation and eastward movement of this fault is not attended by the formation of cyclones except in the far north, where more than likely, one will form, its center first appearing over British Columbia or Alberta, Canada. The completion of the fault and its eastward movement are announced, as stated before, by the indraft of cool air, the incoming of sea fog, and a complete change in the régime that existed prior to and during the time when the fault was in process of formation.

To make clear that which I have brought to your attention, I am showing you charts and graphs. The first of these (fig. 1), gives the average distribution of air temperature as of 5 p. m. in the third decade of July in the far western States. The second (fig. 2) shows the distribution of sea-level pressure for the same time of the year. The third (fig. 3) shows the changing barometric situation determined by standard method that two observers would encounter if they were to ascend vertically over Red Bluff and Eureka, respectively. The observer rising from Red Bluff would ascend through air that is very much warmer than that through which the observer at Eureka would ascend. Consequently, the observer rising over Red Bluff would note that his barometer was falling relatively slowly with ascent as compared with the barometer carried by the observer who ascended over Eureka; also, the observer ascending over Red Bluff would note very quickly that his barometer for any given altitude above sea level beyond an altitude of 2,500 feet would stand higher than the Eureka observer's barometer. The sloping lines indicate the changing isobaric surfaces normally found between these two points under the conditions shown by graphs No. 1 and No. 2. Graph No. 1 brings this out very clearly and shows first that 2,500 feet above sea level is the altitude where the pressure between

the coast and the interior as represented by Eureka and Red Bluff is the same, and secondly, that above that level the barometer over the interior stands higher in comparison with that over the ocean, despite the fact that at sea level the pressure at Eureka was the higher of the two. Consequently, we see that an entirely different régime of winds and pressure gradients is called for above this altitude, 2,500 feet, in comparison with the stratum below it.

Those of you who attended the meeting of the American Meteorological Society in Claremont in 1928 will recall that the question of a changed régime of pressure gradients and winds at high altitudes in comparison with lower altitudes was the subject of considerable discussion. It was then brought out that above the surface system of pressure distribution—namely, high barometric pressure over the coast and low barometric pressure in the interior—there was a complete reversal to high barometric pressure over the interior and low barometric pressure over the ocean. The charts of free-air winds at 4,000 meters of July 8, 9, and 10, 1928, show very clearly the transformation of the sea-level low-pressure system of the interior into a high-pressure system at 4,000 meters altitude. At this level the upper air winds show very definitely that the winds are anticyclonic. Here we have an example of the true Ferrel thermal cyclone.

The accurate forecasting of the changes in wind, weather, and temperature resulting from the formation and degradation of the west coast atmospheric fault calls for great skill on the part of the meteorologist. I am free to admit that I can not always determine from the available data exactly when the fault will begin and when it will be brought to an end. The forecasting of the changes associated with it is essentially different from the forecasting of changes commonly associated with the comings and goings of cyclones and anticyclones. We have made progress in that we know very definitely that we have an atmospheric fault that in our summer months is constantly forming or dissipating, and we shall soon learn its peculiarities and propensities and be able to forecast them.

## THE GROWTH OF THE VESSEL WEATHER SERVICE OF THE NORTHEAST PACIFIC OCEAN<sup>1</sup>

551.509 (265.2)

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Vessel weather reporting by radio was introduced in 1906. The present day reporting service is the outcome of an experiment conducted by the Weather Bureau in Washington, D. C., with the aid of 50 vessels whose captains agreed to take and transmit one meteorological observation daily at a time designated by the Weather Bureau. At a later date two observations were required and a fee of 50 cents paid for each observation taken and successfully transmitted. The results obtained from the extremely limited number of observations sent in were of little consequence and offered slight assistance to the weather forecasters. However, the original series of vessel reports was considered sufficient to prove that such a service could be developed to an untold degree of value in forecasting.

The service was not extended to the Pacific Ocean immediately and in 1907 only one vessel, the steamship *President* of the Pacific Steamship Co., was authorized to make reports. It is understood this vessel was the only one operating on the Pacific which carried wireless equipment at that early date. Lack of wireless apparatus on

ships was one of the principal causes for the slow advance of vessel weather service on the Pacific.

Following the introductory years, the pioneers of this department of the weather work encountered many obstacles. Chiefly among them was the shortage of funds appropriated for observers' fees and radio tolls charged for transmission from ship to shore. Other stagnating influences contributing to the sluggish advance of the vessel service on the Pacific may be summarized as follows:

1. Difficulty in obtaining increased appropriations.
2. Inadequate increases were exhausted with but few new vessel stations established.
3. As mentioned previously, lack of wireless equipment on ships.
4. Seeming slowness of shipping companies to realize the need for wireless or radio equipment.
5. Unreliable radio apparatus with transmission service suffering accordingly and delivery of weather messages uncertain.

It may be readily seen from the foregoing that the struggle to build up the Pacific vessel weather service to a point of real usefulness was a difficult task. Progress was very limited for the first 14 years.

<sup>1</sup> Presented before the meeting of the American Meteorological Society at Berkeley, Calif., June, 1929.

In 1919, authority was granted for the appointment of 12 vessel weather stations. The number of reports received from these ships were insufficient to be of real value but they may be regarded as the entering wedge in the development of the service. Forecasters made only limited use of the observations furnished owing to the desultory nature of the reporting and the vast areas of the ocean unheard from. Systematic plotting of oceanic pressure areas, which is the basis for accurate forecasts and timely warnings in present day forecasting on the Pacific coast, was not possible at this time.

Following the period of uncertainty, a slow but gradual growth began and for two years marked improvement was noted. By the year 1921, the service had reached such a magnitude of importance as to demand recognition from Government officials outside the Weather Bureau, and in January, 1921, all Shipping Board vessels were issued general instructions to cooperate to the fullest extent. The addition of this large fleet to the service reflected gratifying improvement. During this period of progress efforts were made to enlist the aid of Japanese vessels operating between our coast and Japan and north of latitude  $45^{\circ}$ . The serious need for reports from the routes followed by the Japanese made it imperative that we gain their cooperation. These early attempts to secure their assistance were of little avail. Vessel weather stations were established aboard two ships, but after a short time it became apparent that the desired results could not be obtained and the stations were abandoned.

In 1925, Maj. E. H. Bowie proposed that Japanese cooperation be secured through diplomatic channels. Accordingly, the Chief of the Weather Bureau at Washington, D. C., communicated the proposal through these channels to the Japanese Government. Negotiations were successful and the Japanese instructed their ships operating north of  $45^{\circ}$  to report. An interesting point noted in the agreement is the absence of charges for observer's fees. Ship tolls only are paid to the Japanese Government, through diplomatic channels.

In the year following, similar action was taken to secure the assistance of Japanese ships operating south of latitude  $45^{\circ}$ . Favorable response was made to the new proposal with the result that all Japanese vessels were instructed by their Government to send radio weather reports when north of latitude  $10^{\circ}$  and between our coast and the one hundred and eightieth meridian. To-day several of the Japanese vessels are considered among the most reliable and consistent reporters.

Prior to 1928, vessel weather reporting was confined to transoceanic ships and coastwise reports were considered unnecessary. However, increasing demands for more extensive forecasting and warning services called for a study of the situation to determine what additional aid could be procured. After careful deliberation the forecasters at San Francisco amended the rule that had prevented coastwise ships making radio reports. Authorization was requested from the Chief of the Weather Bureau to establish a group of 12 coastwise vessel weather stations. These vessels cover coast points from San Diego, Calif., to Kodiak, Alaska. Reports from Alaskan waters are of the greatest importance to forecasting for the western district. Authority was granted and on July 1, 1929, coastwise vessel weather reporting will be inaugurated.

Early in 1929, the Honolulu Weather Bureau expressed a desire for additional ship reports from adjacent waters. With the assistance of Representative Houston, of

Honolulu, the Isthmian Steamship Line was induced to allow its fleet of 28 vessels to join the ranks of radio vessel weather reporters. This company's ships make more or less regular voyages between the Atlantic coast and the Orient by way of the Panama Canal and Honolulu, thus providing weather observations from areas which have heretofore been poorly represented on the weather charts. The Isthmian Line, realizing the value of the service rendered by the Weather Bureau, directed their fleet to cooperate without charge for observer's fees.

Considering the tardy growth of the vessel weather service for the first 14 years, the following representative figures would indicate a fairly rapid advance for the past 8 years.

There is now a total of 240 vessels reporting weather by radio from the Pacific Ocean; in 1921 there were only 70 vessels. An increase of over 200 per cent. In the first five months of 1929 there has been an average of 50 vessel weather messages received daily; in 1921, 18 messages was the daily average.

To illustrate the importance of vessel weather reporting a short description of the system and the benefits derived from it may be of interest. Simultaneously, at 4 a. m. and at 4 p. m., Pacific standard time, vessel observers on ships en route over the Pacific Ocean, within prescribed limits, take meteorological observations. Coded messages containing the data obtained and the ship's geographic position are radioed through naval or commercial radio land stations to the Weather Bureau at San Francisco. The reports are decoded and the information entered on synoptic weather charts, supplementing the weather reports from land stations. Invaluable meteorological data from ocean areas is made available to forecasters. The depicting of oceanic pressure distribution on the charts is a factor of exceeding importance in forecasting.

Immediately following the construction of the charts the reports are broadcast by radio. To execute the broadcasts the Weather Bureau is given remote control of three radio transmitters at the naval radio station at Mare Island, Calif. There are two periods of broadcasting every 12 hours, beginning at 6:18 and 7:30 a. m. and 6:18 and 7:30 p. m. All broadcasts contain ship reports. Marine and aviation interests receive the greatest benefit but many commercial organizations, vitally interested in weather conditions, derive useful information from the broadcasts. Ships at sea are provided with meteorological data for the construction of weather charts to be used in navigation.

A network of airports extending from San Francisco to Los Angeles have, as a medium of communication, a teletype printing service. Through this teletype system vessel weather reports are transmitted simultaneously to every airway station in the network. Weather charts, similar to the principal chart used in forecasting, are drawn at each airport. From the survey of oceanic meteorological conditions aviators are supplied with valuable flight data.

Vessel reports are a part of the Daily Weather Map issued for the information of the general public. San Francisco, Los Angeles; Portland, Oreg.; and Seattle weather offices publish this type of weather map. The San Francisco Weather Bureau alone distributes over 800 copies.

All of the foregoing activities, the taking of the vessel observations, the centralization of the radio reports, the distribution of them and the data derived from them and the preparation of the printed weather map for

mailing, require a total of slightly over four and one-half hours time.

Due to the successful and extensive development of the vessel weather service comprehensive studies are made of meteorological conditions over the Pacific Ocean. The knowledge of oceanic pressure distribution, the most vital factor in forecasting for the far Western States, becomes available to forecasters. The isobaric reproduction on the synoptic charts of pressure systems as indicated by vessel reports pictures the movements of cyclonic and anticyclonic areas. The continuous eastward march of "HIGHS" and "LOWS" may be closely followed. The constant changing conditions; the rapidity of movement; the relative positions of cyclonic and anticyclonic areas; the intensity of a depression; the steepness of inter-

vening gradients and all the information derived from these factors form the basis for accurate conclusions in forecasting. Without vessel-weather observations forecasters would be confronted with a very puzzling situation.

The value of the forecasting and warnings can not be estimated. Every industry, enterprise, organization, or the individual, whose welfare is affected by weather conditions receives invaluable benefits from this service. Ever increasing demands for a more extensive weather service are taxing the Weather Bureau to capacity. Fairly rapid strides have been made in recent years in the extension of the services of the Weather Bureau and vessel weather reporting has played an important part in the advance.

## METEOROLOGICAL NEEDS OF A CLASS A 1 A AIRPORT<sup>1</sup>

551.5 : 725.39

By D. M. LITTLE

The Secretary of Commerce is empowered by law to rate airports as to their suitability upon application of the owner. After conforming to certain basic requirements, airports may be given ratings indicated by a letter, a figure, and another letter, the first letter indicating the general facilities and equipment at the airport, the figure indicating the available landing area, and the last letter indicating the night flying equipment. Thus the rating A 1 A is the highest rating given airports.

Under general facilities and equipment, an airport, in order to obtain a rating of "A" or "B," must have meteorological instruments including an anemometer, barometer, and a thermometer, in addition to a bulletin board and facilities for giving pilots the most recent weather information. Ratings of "C" or "D" do not require meteorological facilities. Under night-flying equipment an airport must have a ceiling projector, an alidade for measuring the height of ceiling, and sufficient personnel for giving weather service at all times in order to receive a rating of "A." A rating of "B" will be given when an airport is without a ceiling projector, and ratings of "C" or "D" may be given when the airport is without night meteorological facilities or personnel.

The meteorological needs of a class A 1 A airport is much greater than the bare requirements for the rating. In this paper the needs are classified under three headings—Personnel and service, Communication facilities, and Meteorological instruments and facilities.

### PERSONNEL AND SERVICE

1. *Government service at airports.*—At airports designated as control stations on established commercial airways in use more or less 24 hours per day there are ordinarily not less than four Weather Bureau officials on the meteorological staff—i. e., two meteorologists and two observers. At similar stations on established commercial airways where from 15 to 20 hours' service per day is sufficient for the present flying one meteorologist and two observers are usually assigned. At all other airport stations and aerological stations 12-hour service is maintained by the assignment of one meteorologist and one observer. Employees below the rank of junior observer should not be assigned to airport stations, as the responsibility is too great to be placed with men of lesser capacity. Service at Weather Bureau airport

stations is progressing at a fast pace. Experience has shown that close contact between the meteorologist and the pilot is absolutely necessary, and this mutual exchange of meteorological information and flying problems is conducive to safe and economical air transportation.

2. *Municipal service at airports.*—Many large and important municipal airports over the country, located on and adjacent to established airways, will not be needed as Weather Bureau airway control stations, and therefore will be without Government meteorologists. However, Government airway weather and communication service is available at small cost to such airports, but it is necessary for the municipalities to employ their own meteorologists. This has already been done in several instances, and the airports are rendering as efficient service as at the Weather Bureau airport stations.

3. *Service at privately owned airports.*—The need for meteorological service at a privately owned airport where air-transport operations are carried on is just as great as at a municipal airport. Here, again, it will be necessary for the airports or air-transport companies to employ their own meteorologists. In some cases it will be necessary for an air-transport company to employ one or more meteorologists, placing them at strategic points along their particular flying route when such route does not follow the established commercial airway. One company has already set aside \$100,000 for its own complete meteorological service along such a route.

Private and municipal airport meteorologists, of course, should be experienced and thoroughly familiar with the aerological, marine, and weather codes of the United States Weather Bureau. With the wealth of information available, as explained later under "Communications," the meteorologist can prepare synoptic maps of 12-hour weather conditions, tabulate and map hourly airway weather reports supplemented with 3-hour summarizations and short-range forecasts based on off airway reports, prepare multilevel maps of upper air winds, and furnish all pilots with current weather reports in tabular form. In addition he would advise the pilot of the best weather route, how high to fly in order to take advantage of "tail winds," and the weather changes to be expected during a flight along an off airway route. In short, he would render for the municipal and privately owned airport all of the service available at a Government station and devote a portion of his time to research on meteorological problems particularly affecting his area.

<sup>1</sup> Presented before the Berkeley meeting of the American Meteorological Society in June, 1929.